

Technical Assessment for the CPC FD-7x-1500 Wind Turbine Located at Tooele Army Base, Tooele, Utah

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Executive Summary

The CPC FD-7x-1500 Wind Turbine was installed with funding from the Energy Conservation Investment Program (ECIP). Since its installation, the turbine has been plagued with multiple operational upsets causing unacceptable down time. In an effort to reduce down time, the Army Corps of Engineers requested the Idaho National Laboratory conduct an assessment of the turbine to determine its viability as an operational turbine.

The Idaho National Laboratory conducted a preliminary site visit to the Tooele Army Depot on May 10-11, 2012. On 08/01/12 thru 08/03/12 a follow-on visit was conducted with assistance of an O&M contractor to assist assess, inspect and correct issues encountered.

The turbine has been found to be in good shape overall, but lacks Operational and Preventative Maintenance (O&M). The Down Tower Assembly looked good and intact. The Tower section and platforms looked good. The cables going up-tower also looked to be in good shape. The hub is in good shape overall. Wiring appears to be adequate, however several issues were corrected. The Turbine blades need to have a more intense inspection and be repaired ASAP; if further spalling or delaminating occurs, the blades may not be repairable and will potentially need to be replaced.

An intense End of Warranty Inspection needs to be conducted, with all grease and oil analyzed. A better set of spare parts should be funded and obtained. A qualified, reputable and experienced wind turbine O&M contractor needs to be subcontracted as soon as possible for this turbine. Remote communications capability for this wind turbine needs to be updated/changed to improve the O&M and availability of this turbine.

This turbine has been in operation without faults since the visit of August 1-3, 2012.

Purpose

Conduct a technical assessment for the CPC FD-7x-1500 Wind Turbine located at Tooele Army Base, Tooele Utah, as requested by the Corps of Engineers Sacramento California.

Turbine STATUS SUMMARY

Background:

The CPC FD-7x-1500 Wind Turbine was installed with funding from the Energy Conservation Investment Program (ECIP). Since its installation, the turbine has been plagued with multiple operational upsets causing unacceptable down time. In an effort to reduce down time, the Army Corps of Engineers requested the Idaho National Laboratory conduct an assessment of the turbine to determine its viability as an operational turbine.

The Idaho National Laboratory conducted a preliminary site visit to the Tooele Army Depot (here after referred to as Depot) on May 10-11, 2012. The purpose of the visit was to gather preliminary information of the Operation of the CPC FD-7X-1500 turbine, to further conduct an operational assessment of the turbine.

The turbine is currently under a one year warranty subcontract that expired in May 2012 (Army Corps attempted to extend this warranty with CPC, and has been successful in the extension until July 2012). The warranty covers defective parts.

There is not an Operation and Maintenance (O&M) contract currently in place. In order to do full due diligence in assessing the operations of the turbine, many of the nuisance trips and outages must be eliminated. The INL submitted a RFP, on 06-01-12 to an authorized/certified O&M contractor to assist in making operational and recommended changes, and to prevent void of warranty by an unauthorized contractor.

The warranty provider has been addressing the major items on this turbine, but is not addressing very well the smaller items to get this turbine to a respectable availability. This is a result of many factors that the Army should start to address through attempts to improve parts availability, O&M arrangements and qualifications/training, and working on better remote monitoring and control options.

This turbine has a lot of nuisance trips/shutdowns that can likely be addressed with better O&M, parts and technical/engineering support. Just adjusting a sensor, when it actually needs to be replaced, or resetting a turbine without addressing the root engineering/controls/hardware issue causing each shutdown will not lead to acceptable long-term availability on this turbine.

Observations and Findings:

On 08/01/12 thru 08/03/12 a follow-on visit was conducted by the INL with assistance of an O&M contractor (hereafter referred to as the team) to assist in inspecting and correcting issues encountered. The following is a summary of the findings.

Past History

The Tooele wind turbine has a long list of past problems and error codes that occurred over the first two years of operation. Detailed lists and descriptions of many of these issues are available through the Army Corps and the local Base engineer overseeing the turbine. A short list of some of the issues includes:

1. Early in the operations of the turbine, it was reported that a generator bearing heater and error display failed, causing operation outside of lubricant temperature range and leading to generator bearing failure. This also led to a bent generator shaft. INL was not involved at the time so cannot confirm the issues nor if there was some other cause of the problem (such as a misalignment). Either way, the whole generator and bearing apparatus was replaced under warranty, but there was significant downtime and lost generation.
2. Abnormal wear on the friction plates for the turbine yaw system led to many vibration errors and shutdowns. After many shutdowns and visits, the Chinese technician finally diagnosed the root cause of the problem, parts were ordered and repairs made.
3. Numerous pitch control and other errors have plagued the turbine over the first two years. As of August 3, 2012, most if not all of the issues causing these errors had been corrected. The major root causes of these errors likely stemmed from a relay in the pitch control system that was finally diagnosed and replaced by the Chinese technician, and an over temperature issue being caused by a jammed pitch control motor cooling fan (INL and subcontractor found this in August 2012 and made the repair). There were also other issues in the pitch control system and hub that were addressed over time, such as damage caused by a control door that came loose, loose wires, etc. It appears that the damage caused by the door that came off in the hub led to replacement of several parts by the Chinese tech.
4. The jammed cooling fan/motor on the pitch motor found by INL in August 2012 was caused by a missing snap ring on the end of the fan shaft that should hold it in place on the back end of that motor. It appeared that this snap ring was never there, as no broken ring parts or shaft marking could be found. This motor and pitch control assembly in the turbine hub were from standard OEM suppliers for many wind turbines. It appears that QC checks from the original supplier and the final turbine manufacturer/integrator missed this issue. It also went unnoticed for almost two years of turbine operation and warranty repair/maintenance. Since this would lead to intermittent problems and error signs depending on ambient and system temperatures, it could be difficult to diagnose. Also, since the turbine has run well since this repair,

it is likely that temperature cycles related to this cooling fan and the pitch system were the root cause of many of the pitch control shutdowns.

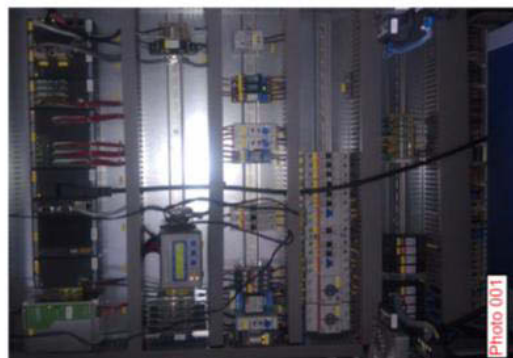
5. One of the turbine blades is in need of significant repair. The cracking and peeling appears to be mostly on the surface and not structural, but could not be confirmed by INL, as the close-up inspection and report had been performed by others and INL has not reviewed the report. Moisture/freezing, temperature changes, and prolonged operation of the turbine will likely exacerbate the problem. This blade damage was identified before warranty was up, so should be repaired or replaced as soon as possible under warranty. There will likely be disagreement between the manufacturer, potential repair subcontractors, and the original turbine installation contractor as to the severity of the damage, what caused it, and how it should be repaired. The Army should stay cognizant of this, but insist that it be repaired or replaced to the satisfaction of a quality inspection by a qualified subcontractor to the Army, and should come with at least a one year warranty extension on the blade/repair. The other two blades have spots that also need surface repair. It appears that some of the damage is in areas where lifting or storage straps would have been placed on the blades, and indications of strap marks are left in those spots. Normally lifting would not cause undue stress on those parts of the blades, but prolonged flapping of straps on a spot during winds and storage/shipping could cause some extra stress, or poor original surface quality could potentially be impacted during a strap lift.

Visual Inspections (May and August 2012)

The inspection team found the turbine to be in generally good shape. The Down Tower Assembly looked good and intact. The team checked all cabinets and saw some rewiring done in the Main Control Cabinet and the Top box Cabinet; photo #001, #002, and #003. The Tower section and platforms also looked good, although there were a few bolts on the platforms and platform door hinges that need to be replaced or tightened. The cables going up-tower also looked to be in good shape; photo #004. The Nacelle is in good shape, but did find the rotor lock missing which was later found in a shed with turbine spare parts; the rotor lock shaft was bent and had to be lathed to temporarily fit back in to lock the rotor for hub work; photo #005, #006, and #007, and also see additional photos. A new rotor lock shaft is supposedly on order, so should be fully replaced and installed in the future.

The high-speed brake caliper had leaked at some point, techs found hydraulic fluid on the tray underneath the gearbox; photo #008 and #009. The hub is in good shape overall. The team did find wires inside the center pitch control box with cracked and peeling insulation and a loose connection, the team taped the wires with electrical tape and fixed the connection; photo #010 and #011. The turbine faulted on PCS errors (codes “Pcs Any Error”, “Pcs Failure A”, and “Pcs Failure B”), which after 15 min. the turbine reset itself and started up. The team found one of the pitch motor cooling-fans to be jammed inside its casing which caused the pitch motor to overheat

and fault out the pitch controller. The team repaired the cooling fan; photo #012. The turbine had a fluctuating rotor speed rpm, the team cleaned and adjusted the rotor speed sensor which fixed the issue; photo #013. The team performed a Generator alignment check and found the generator to be well within tolerance; photo #14.





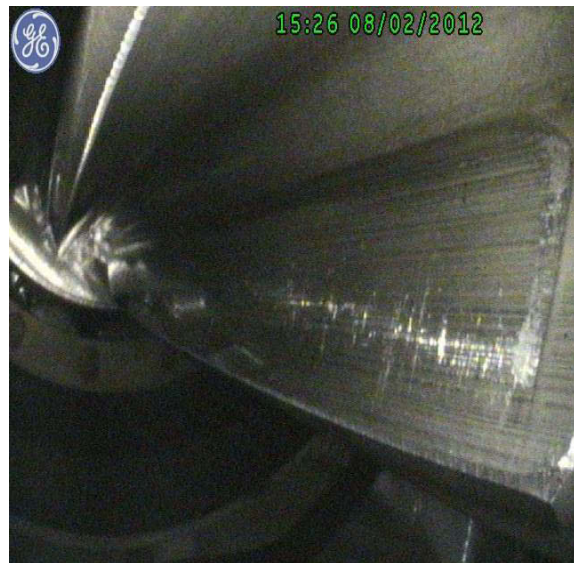
Borescope Check

A Borescope was also performed on the gearbox and found some potential issues or problems to be watched over time.

The High Speed Pinion showed somewhat heavy scuffing (Pictures 1&2); Intermediate Wheel and Low Speed Wheel showed minor adhesion (Pictures 3 thru 8), High Speed Generator Side bearing and Low speed Rotor side bearing showed mild scoring on the rollers (Pictures 15 thru 24). Our feeling is that this wear is within typically normal bounds for a wind turbine gearbox, but likely on the high side of normal wear for the amount of time this turbine has run so far. This may be due to the gusty nature of the wind resource at Tooele, or could be an indication of gear material quality to watch over time, but this may be just speculation. We recommend regular inspections of the gearbox, lubrication fluid testing, and making sure that all of the turbine lubrication systems are checked and verified to have been performed on the manufacturer-recommended intervals.



High Speed Pinion Picture 1



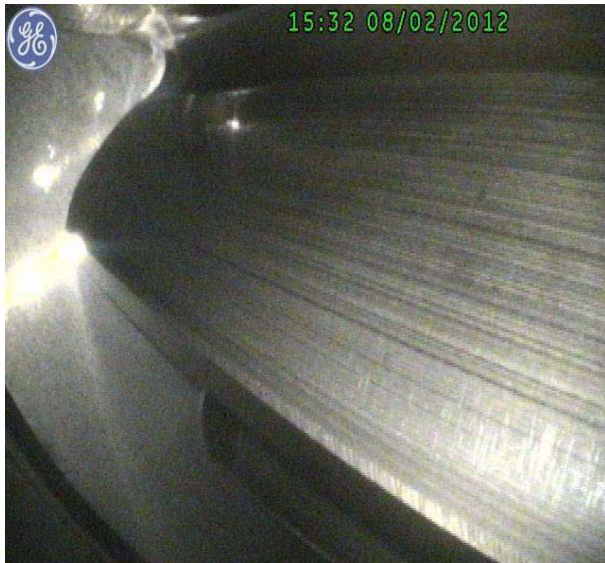
High Speed Pinion Picture 2



Intermediate Wheel Picture 3



Intermediate Wheel Picture 4



Intermediate Pinion Picture 5



Intermediate Pinion Picture 6



Low Speed Wheel Picture 7



Low Speed Wheel Picture 8



Planetary Ring Gear Picture 11



Planetary Ring Gear Picture 12



High Speed Rotar Side Picture 13



High Speed Rotar Side Picture 14



High Speed Generator Side Picture 15



High Speed Generator Side Picture 16



15:45 08/02/2012

Intermediate Rotar Side Picture 17



15:48 08/02/2012

Intermediate Generator Side Picture 18



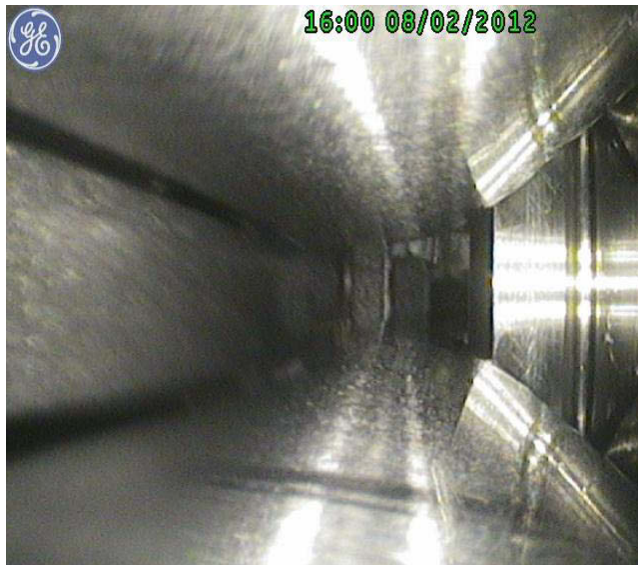
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Low Speed Rotor Side Picture 19



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Low Speed Rotor Side Picture 20



Low Speed Generator Side Picture 21



Low Speed Generator Side Picture 22



Planetary Rotor Side Picture 23



Planetary Rotor Side Picture 24

Power Monitor and Evaluation

The team conducted power quality monitoring and data logging to evaluate the power coming out of the generator.

The results indicate that the turbine generally has satisfactory power quality, although the power factor at low output power fluctuates a bit more than is typical for a doubly-fed induction generator and power electronics system. The power factor at higher output power is very stable. The power factor at low output power varies quite a bit, more like a standard induction generator wind turbine with switched capacitor banks, without the finer power electronic controls and capacitor bank/stages sizing. Harmonics appear to be within acceptable ranges. Even though the power factor fluctuated at low power output, the system voltage was relatively stable overall at

the measurement point. Feeder and power system voltages around the Tooele distribution system should be monitored periodically in the future, and if there are power quality or voltage concerns, system designers may revisit the turbine power controls or other system voltage control methods and equipment for the Base and between the Base and service utility. Figure 1 shows plots of the measured output power and power factor from the wind turbine during the test period. Figure 2 shows plots of the measured current and voltage from the wind turbine during the test period. Other plots of voltage, current, harmonics and other parameters are available on request.

Figure 1: Active Power and Power Factor Plots

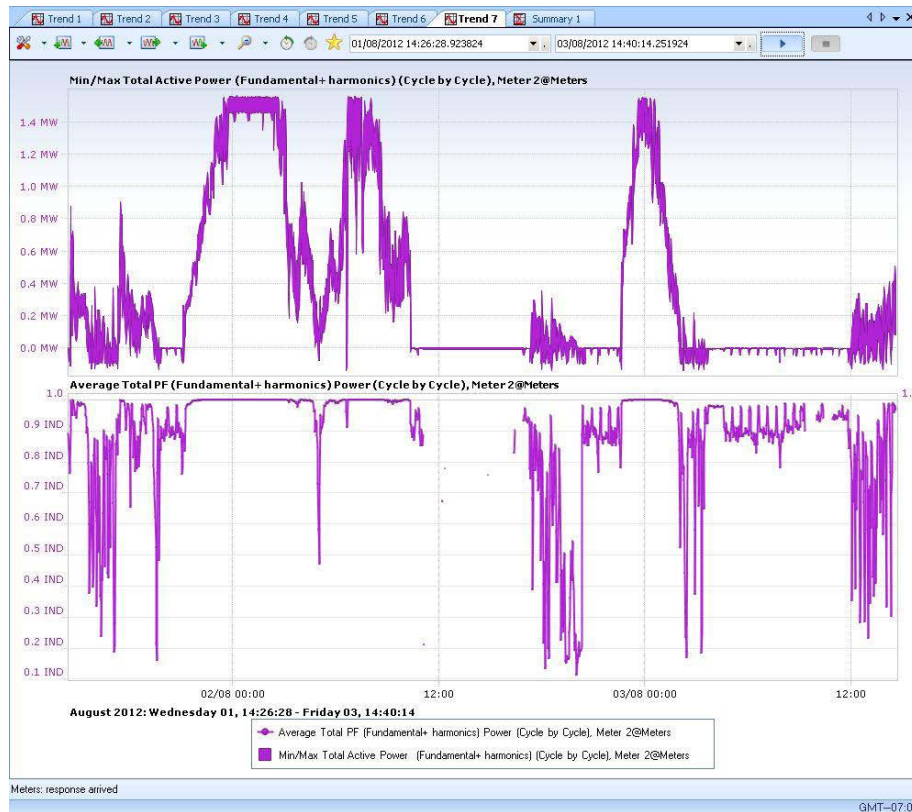
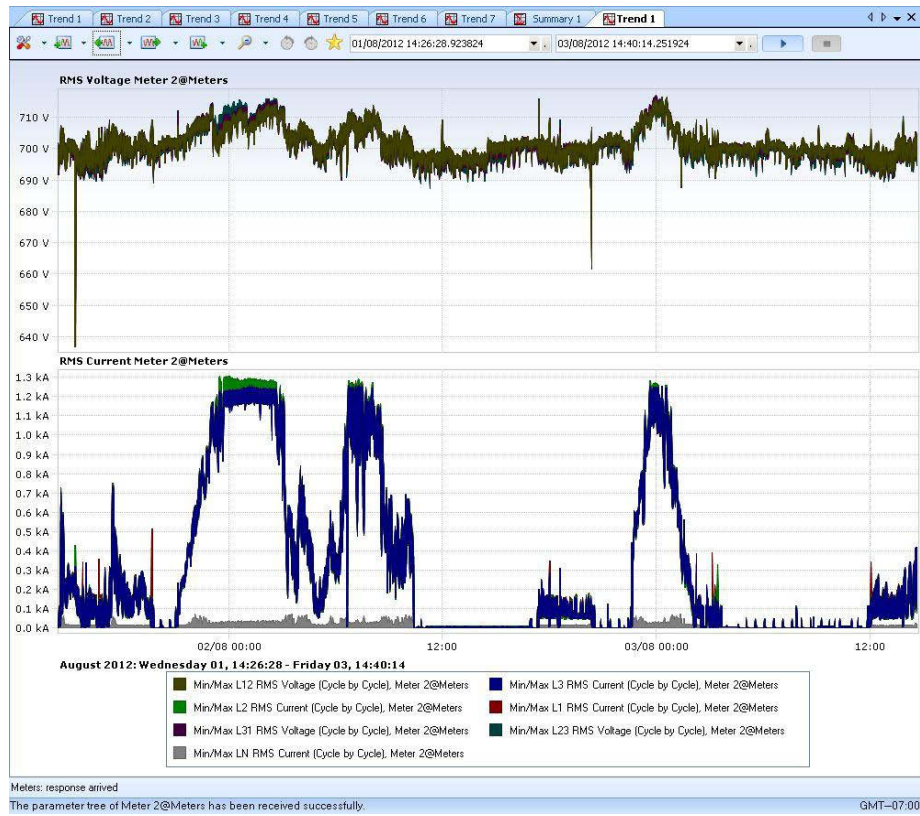


Figure 2: Voltage and Current Plots



The Turbine Blades

The blades were visually checked and found some cracks which need to be repaired ASAP, Pictures B1 thru B6 Illustrate the cracks on the blades.



Picture B1

Picture B2



Picture B3



Picture B4



Picture B5



Picture B6

Picture B7 illustrates the marking in the tip of the blade, further inspection is recommended. Picture B8 shows venting on blade has been removed and plugged.



Picture B7



Picture B8

Recommendations

1. An intense End of Warranty Inspection with all grease and oil analyzed.
2. An intense maintenance should be done with torque checks and cleaning.
3. All power cabinets should be tweaked and checked again/periodically for any loose connections.
4. Gearbox defects may lead to potential damage if not monitored.
 - a. Borescope re-inspections in 12 months to monitor the condition of the gearbox
5. Gearbox oil analysis should be conducted.
6. The blades need to be inspected and repaired ASAP; if further spalling or delaminating occurs, the blades may not be repairable.
7. A better set of spare parts should be funded and obtained, especially with some of the larger items that might have a higher probability of replacement frequency, such as pitch motor, yaw motor, hydraulic pump/motor, pitch motor cooling fan/motor, yaw plates, etc. Checking with the manufacturer, OEM suppliers, and/or the selected turbine O&M contractor for recommended spare parts would be a good first step in developing a better list of spare parts for this turbine. There are several smaller spare parts currently at the site, but these are mostly electrical components.
8. A qualified, reputable and experienced wind turbine O&M contractor needs to be subcontracted as soon as possible for this turbine. INL recommends that this be done through a competitive, well-reviewed process (with performance requirements) so that issues and second-guessing questions are minimized moving forward. Access to varied experiences and more sets of eyes will be important to keep this turbine running, as shown by the long down times resulting from the previous warranty/repair arrangement where only one individual with limited experience was available.
9. The selected O&M contractor should have availability requirements to keep the turbine running, such as 92% or better. This may be subject to review or extra allowance if spare parts availability and forces outside of the contractor's control impact their ability to keep the turbine at acceptable availability. Availability requirements of 95% or better are common at typical larger wind farms, but this may be difficult to achieve with the lack of economy of scale with just one turbine.
10. The remote communications capability for this wind turbine needs to be updated/changed to improve the O&M and availability of this turbine. The O&M provider will need remote access to the SCADA system to monitor and troubleshoot the turbine without always having someone in the local area. This will require coordination with communications/IT systems and departments to maintain acceptable security levels. The existing communications system cannot be kept at a level where no one outside the Base can access it or receive notifications (right when an alarm/shutdown occurs), if better availability is desired for this wind turbine.

Additional Photos:

Figure 3: Damage to Rotor Lock Wheel



Figure 4: Damage to Rotor Lock Wheel



Figure 5: Rotor Lock Shaft Repair



Figure 6: Rotor Lock Shaft Repair

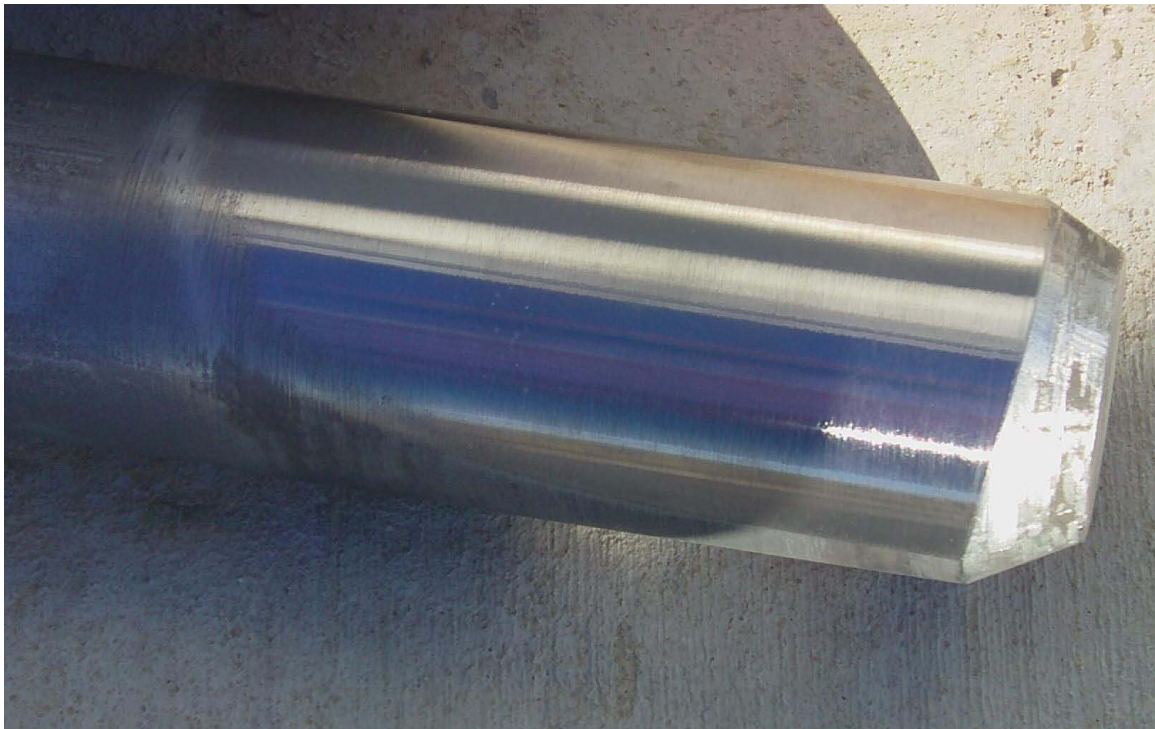


Figure 7: Repairing Cooling Fan for Pitch Control Motor

